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**[A STUDY OF TUNGSTEN-TECHNETIUM ALLOYS]**  
**OCTOBER 1, 1965-JANUARY 1, 1966)**

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QUARTERLY PROGRESS REPORT  
A STUDY OF TUNGSTEN-TECHNETIUM ALLOYS  
OCTOBER 1, 1965—JANUARY 1, 1966

By

The Staff of Metallurgy Development Section  
Reactor and Materials Technology Department

Sponsored by the National Aeronautics and Space Administration  
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INTRODUCTION

Technetium is a sister element to rhenium and has many properties that are similar to rhenium. It is predicted that technetium will have about the same effects on tungsten as rhenium in regard to increase in workability, lowered ductile-to-brittle transition temperature, and improved ductility.

The objectives of the current work are to recover technetium from fission product wastes at Hanford and reduce to purified metal; prepare W-Tc alloys containing up to 50 at.% Tc; fabricate the alloy ingots to sheet stock, assessing the effect of technetium on workability; and perform metallurgical and mechanical property evaluation of the fabricated alloys.

Previous reports have described the separation and purification of 800 g of technetium metal powder, melting of technetium and W-Tc alloys, and some properties of the arc cast alloys.

CURRENT PROGRESS

During the past quarter the remelting of the alloys by electron beam melting was completed, radiography and density measurements made, and buttons were sealed in molybdenum cans by electron beam welding in preparation for fabrication.

It was necessary to break up the arc cast buttons prior to electron beam melting. Alloys up to 30 at.% Tc and the 60 at.% Tc alloy were broken with hammer blows. The fracture surfaces shown in Figure 1 indicate the marked effect of technetium additions on the cast grain structure. Alloys of higher technetium content could not be broken in this manner and required repeated blows of a 6000 lb pneumatic hammer to fracture. The

50 at.% Tc alloy was particularly difficult to break and was cold forged as indicated in Figure 2. This alloy is approximately the limit of solid solubility in the as-cast condition.

The melting was performed in a 10 kW electron beam evaporator unit in a four-compartment water-cooled copper crucible at a pressure of approximately  $5 \times 10^{-7}$  Torr. Alloys up to 30 at.% TC were difficult to melt and solidify into a well formed button. Alloys of higher technetium content melted much more smoothly, probably due to the lowered melting point. Losses ranging from zero to approximately 8 g out of about 30 g occurred during melting due to evaporation and spatter. Radiographs of the remelted buttons indicated that essentially all of the porosity observed in the arc melted material was eliminated.

The alloys were all given a homogenization anneal prior to canning for fabrication to help relieve the coring observed in the structure of the arc cast material. This treatment consisted of the following cycle in hydrogen atmosphere:

<u>Heating</u>	5 hr to 1200 °C
	16 hr at 1200 °C
	2 hr to 1700 °C
	70 hr at 1700 °C
<u>Cooling</u>	3 hr to 800 °C
	~5 hr to room temperature

The material was in contact with tungsten throughout this cycle. No contamination of the furnace interior or exit gas was observed and the alloys were removed with clean, lustrous surfaces.

The densities were determined by weighing in air and  $\text{CCl}_4$ . These values are shown in Table I and Figure 3.

TABLE I  
DENSITY OF W-Tc ALLOYS

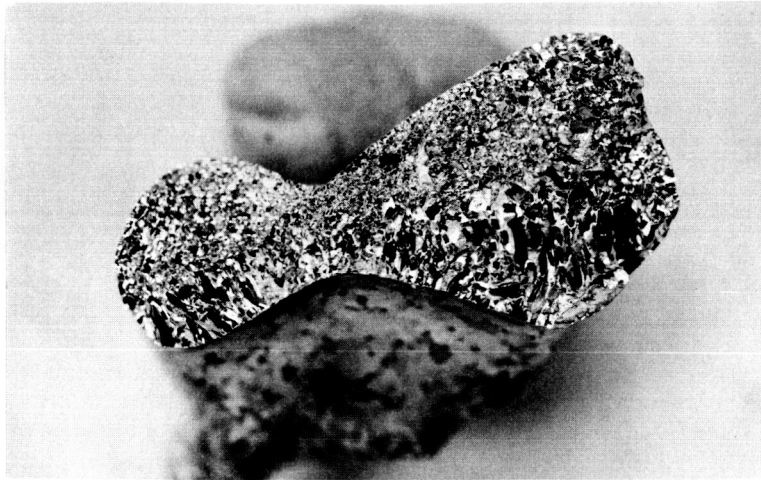
<u>Alloy No.</u>	<u>Intended Composition at.% Tc</u>	<u>Density g/cm<sup>3</sup></u>
1	2.5	19.306
2	3.5	19.301
3	5.0	19.215
4	5.0	19.327
5	10.0	18.976
6	10.0	19.316
7	20.0	18.627
8	20.0	19.217
9	30.0	18.171
10	30.0	18.511
11	40.0	16.518
12	40.0	16.256
13	50.0	15.496
14	50.0	15.479
15	60.0	14.628
18	0	19.330

The only explanation for deviation from theoretical density is the selective evaporation of technetium during melting. The losses were not as significant at the higher technetium levels. This is felt to be due to the lowered melting points and accompanying lower vapor pressure of technetium. A preferred sequence of alloy preparation would be initial electron beam melting of the individual components for gas removal, followed by inert gas arc melting to form the alloys. A further check on composition will be made after fabrication by measuring Tc<sup>99</sup> activity and lattice parameters of the alloys.

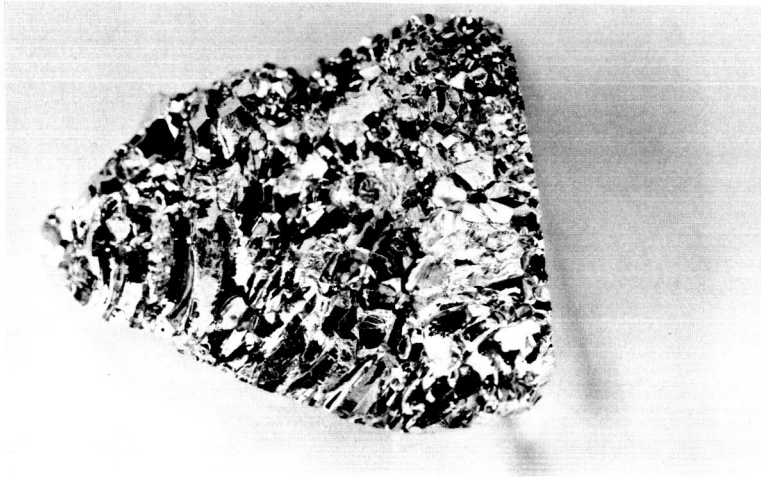
The alloy buttons were sealed in molybdenum cans 1 1/2 in. OD x 3/16 in. wall thickness and 3/4 in. height by electron beam welding end caps in place. The can stock will serve as protective cladding during heating and fabrication.

A section of electron beam melted pure technetium, previously hot forged to 0.047 in. thickness, was hot rolled to 0.015 in. thickness at approximately 1500 °C in eleven roll passes. The metal was clad with 0.030 in. thick sheets of molybdenum, heated in a hydrogen furnace adjacent to the rolls of the mill, and cooled in a hydrogen atmosphere chamber on the exit side of the rolls. The molybdenum was chemically stripped, revealing a rough irregular surface on the technetium (Figure 5). A section was sheared without producing cracks. Examination of the microstructure (Figure 5) revealed complete recrystallization with a grain size of about 0.150 mm average grain diameter.





W-20 at.% Tc



W-10 at.% Tc



W-5 at.% Tc

FIGURE 1  
Fracture Surface of Arc Melted W-Tc Alloys  
5X





FIGURE 2  
Fracture Surfaces of W-50 at.% Tc Alloy  
Showing Cold Deformation  
5X

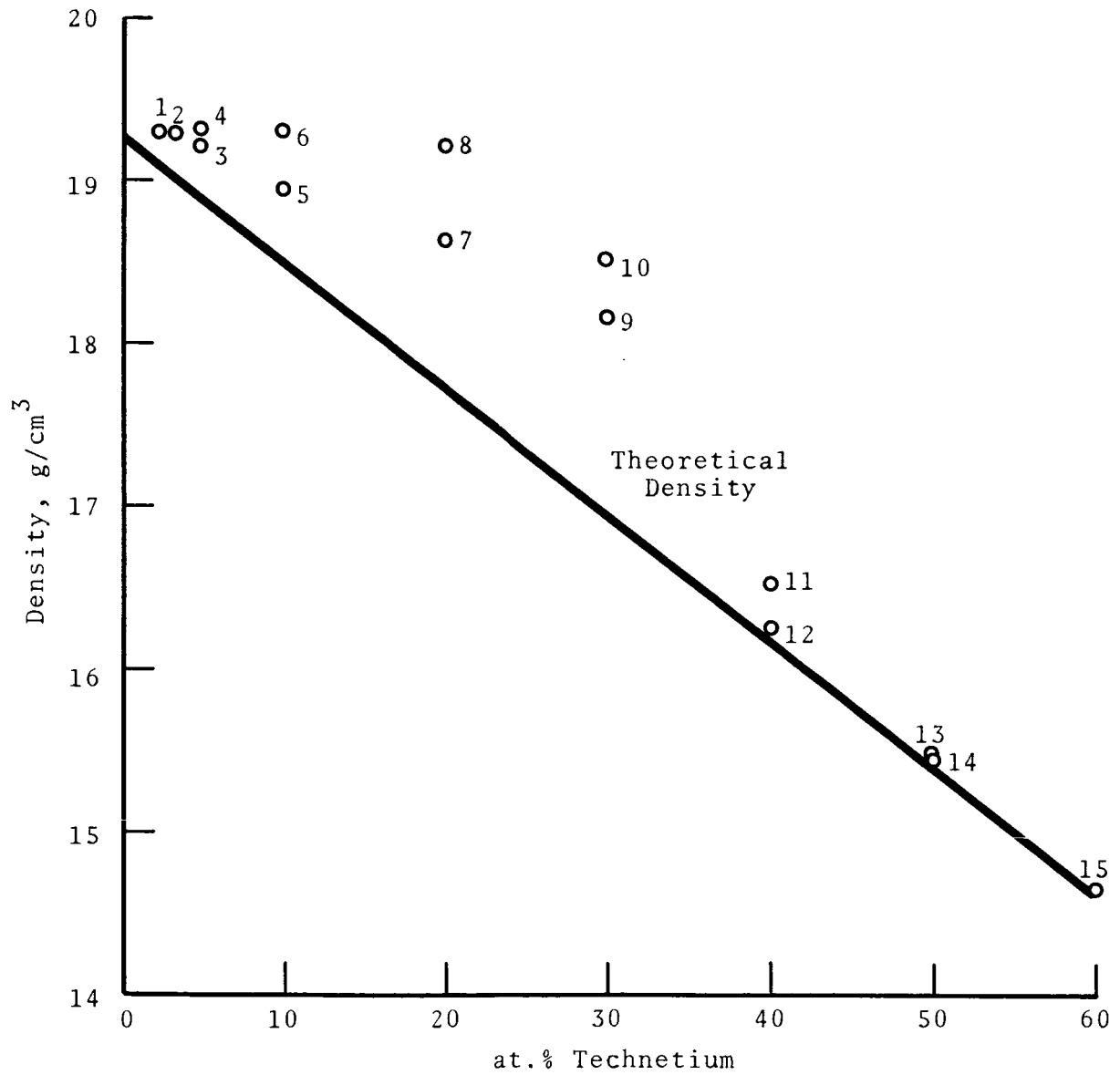


FIGURE 3  
Density of Electron Beam Melted W-Tc Alloys

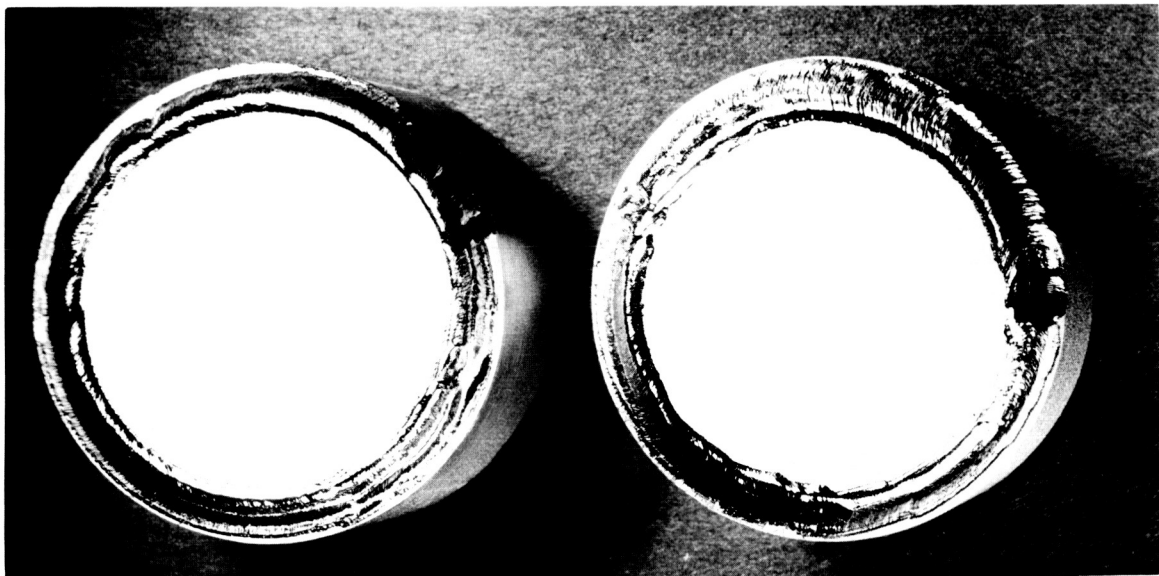
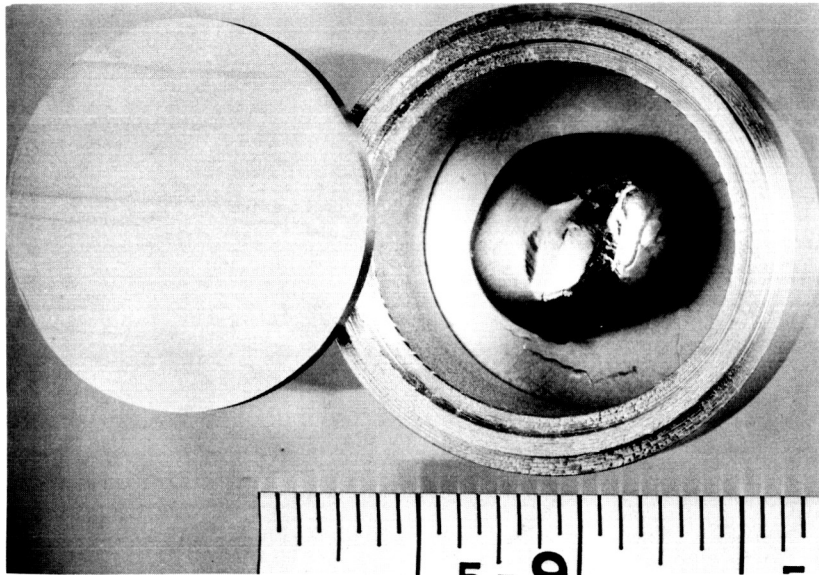
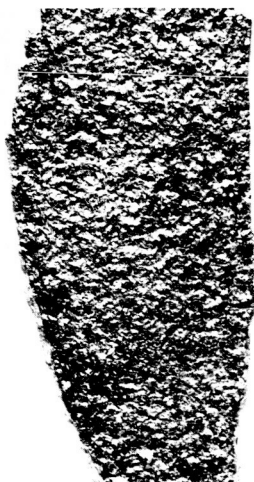


FIGURE 4

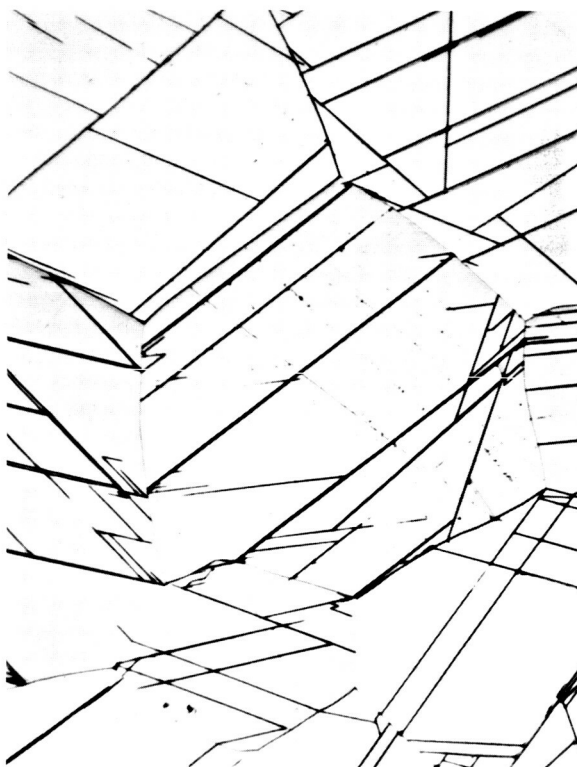
Assembly of Alloy Buttons in Molybdenum Containers  
by Electron Beam Welding



Microstructure  
250X



Surface  
3X



Microstructure  
750X

FIGURE 5  
Electron Beam Melted  
Pure Technetium, Hot Rolled  
70% Reduction at 1500 °C

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